

MAINTENANCE OF PVC SEWER PIPE

UNI-TR-3-03

A technical report prepared by the:



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ABSTRACT

The Technical Report provides review and evaluation of maintenance requirements for PVC sewer pipe manufactured to meet ASTM D 3034 (SDR 35). PVC sewer pipe response to aggressive environments typical in gravity-flow sanitary sewer systems is evaluated. Recommendations are provided for cost-effective maintenance procedures for PVC sewer pipe systems. Information and recommendations were obtained from system managers, maintenance personnel, pipe manufacturers and equipment manufacturers. Supporting data were obtained from field evaluation and laboratory research. Experience and research demonstrate that PVC sewer pipe provides viable solutions to many common maintenance problems.

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Table of Contents

RESEARCH DATA INDEX.....	3
INTRODUCTION.....	4
AGGRESSIVE ENVIRONMENTS.....	4
RESPONSE TO AGGRESSIVE ENVIRONMENTS.....	5
Root Intrusion.....	5
Infiltration.....	7
Slime Accumulation and Corrosion.....	8
Grease Deposition.....	9
Obstructions.....	9
Grit Accumulation.....	12
Abrasion.....	12
RECOMMENDED PROCEDURES FOR MAINTENANCE.....	13
CONCLUSION.....	14
BIBLIOGRAPHY.....	15

MAINTENANCE OF PVC SEWER PIPE

INTRODUCTION

Sanitary sewer system operators today cannot yield to the false security derived from the antiquated philosophy, "bought, buried and forgotten." Without question, wastewater collection and treatment have become a huge and vital industry throughout the civilized world. Such big business demands a big effort in cost effective management.

The design, installation and operation of sanitary sewer systems must assure predictable and affordable long-term performance cost. An essential element of long-term performance cost is the cost of system maintenance -- both scheduled preventive maintenance and unscheduled emergency repairs.

This technical report is dedicated to the review and evaluation of maintenance requirements for PVC sewer pipe manufactured to meet ASTM D 3034 (SDR 35 and SDR 26). The principal objectives in this analysis are as follows:

- Evaluate PVC sewer pipe response to aggressive environments typical in gravity-flow sanitary sewer systems.
- Provide recommendations on cost-effective maintenance procedures for PVC sewer pipe systems.

In pursuit of these objectives, information and data were obtained from the following sources:

- Sanitary sewer system managers
- Sanitary sewer maintenance personnel
- Field evaluation
- Laboratory research
- Equipment manufacturers
- Pipe manufacturers

AGGRESSIVE ENVIRONMENTS

A sanitary sewer system is commonly considered to be a harsh environment. Various aggressive elements work together ceaselessly in the attempt to compromise the integrity of a sanitary wastewater collection system. Essentially, all system maintenance is designed to provide the following:

1. A clear, unobstructed pipe bore.
2. A seal in pipe and joints which limits infiltration/exfiltration to minimum levels.
3. Effective collection and transport of wastewater.

System integrity and capacity in most sanitary sewers is commonly challenged by a number of aggressive environments including the following:

Root intrusion	Abrasion
Infiltration	Grease deposition
Excessive slime accumulation	Grit accumulation
Corrosion	

Problems in some sewer pipes can force the need for emergency repairs:

Shear breakage	Obstruction
Beam breakage	Severe deterioration
Cracking	Collapse

In summary of potential aggressive environments, it should be reported that the greatest concerns commonly reported were as follows:

1. Root intrusion
2. Excessive infiltration
3. Corrosion

RESPONSE TO AGGRESSIVE ENVIRONMENTS

Root Intrusion. When considering root intrusion, it is commonly conceded by engineers and operators that prevention of root intrusion is imperative in modern wastewater collection systems. Such a requirement dictates (1) that pipe joints must not leak and (2) that pipe must not crack. Any opening in the pipe or its joints which can permit leakage can provide access for tree roots.

The manager of collection system operations for a major sanitary district in California discussed the problem, "My first concern is the pipe product's joint. Will it leak? Is it root proof? Will debris hang-up on it?" He explained that the biggest problem experienced in his system maintenance is caused by root entry at pipe joints.

The manager's concerns are typical. His experience with PVC sewer pipe with gasket joints is also typical. He had found no root intrusion problems with PVC sewer lines. It is commonly recognized that PVC sewer pipe with gasket joints as commonly installed is not vulnerable to root intrusion.

A PVC sewer pipeline which had been in service in Oregon for over six years without cleaning was recently televised. The system manager was particularly concerned about root intrusion since most of his system was plagued by root problems. The line was surprisingly clean. No roots, no significant grease deposition and no significant sliming were noted in the PVC sewer line.

Research was conducted in Pell City, Alabama to evaluate the integrity and root resistance of PVC sewer pipe gasket joints manufactured in accordance with ASTM D 3212. In July 1977, six PVC sewer pipe joints (6" diameter, ASTM D 3034, DR 35) were assembled in a continuous piping assembly and then installed in a soil box. A seven-foot weeping-willow

tree was then planted directly over the pipe joint assembly. (See Figure 1.) A constant flow of well water through the pipe joint assembly was provided for the duration of the test. After 15 months of exposure, the test was concluded when the tree died due to lack of water. Pipe joints were examined at the conclusion of the test. No root penetration occurred in the joints even though numerous "hair fine" roots were embedded in the soil around the lip of each bell.

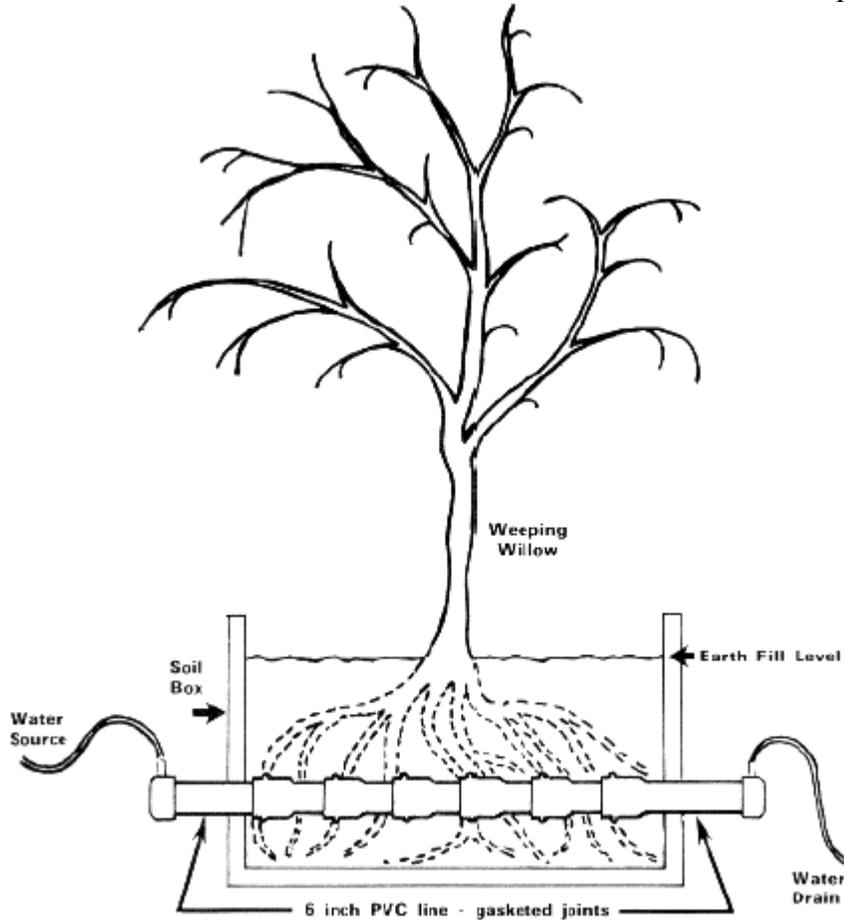


FIGURE 1
ROOT RESISTANCE RESEARCH

Concern has been expressed by some sanitary sewer system operators that PVC sewer pipe joints could leak and permit root intrusion if subjected to "excessive deflection." Research was conducted at the Utah State University Buried Structures Laboratory to evaluate the performance of integral bell gasket joints when deflected by severe earth loading conditions. The gasket joints tested were manufactured to meet the requirements of ASTM D 3212.

Tests were conducted on eight inch PVC sewer pipe (ASTM D 3034, SDR 35) with integral bell gasket joints. Test specimens were installed in sandy silt. Soil densities were measured using a nuclear density gauge. Tests were conducted in embedment soils placed

with 85 percent standard Proctor density and in embedment soils with 65 percent standard Proctor density (AASHTO T-99). Specimens were tested under loads equivalent to buried depths greater than 35 feet. Abusive conditions were created by placing a 10-pound rock on the male spigot end next to the bell joint. (See Figure 2.) Joints were tested with 3.5 psi air pressure held for five minutes. Results obtained in this research are summarized in Table 1.

Both field experience and laboratory data clearly demonstrate that PVC sewer pipe with gasket joints, properly installed, is not subject to root intrusion. Obviously, use of saws or augers for root removal in PVC sewer pipe cannot be considered necessary. The division engineer for a major metropolitan district in Connecticut advised, "We have no record of root infiltration in PVC pipe. Keep in mind that all (of our PVC) joints are made with compressed rubber rings and these joints are more or less common with all piping materials used today. We believe, however, that the types of joints used on PVC pipe utilizing rubber gaskets are the best we can obtain."

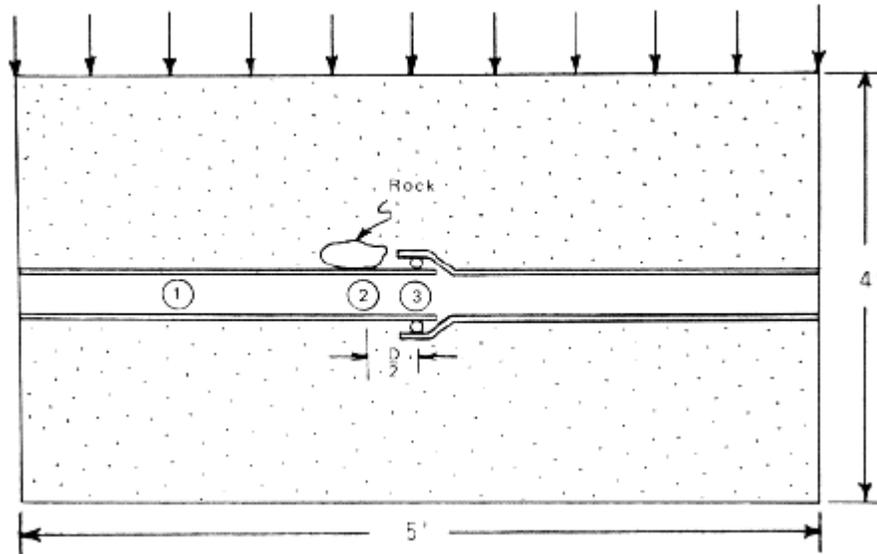


FIGURE 2
ABUSIVE TEST CONDITION FOR PVC JOINT TEST
IN SOIL CELL WITH TEN POUND ROCK ON SPIGOT END

TABLE 1
RESULTS OF PVC JOINT TEST

Test No.	Test Description	Percent Deflection When Test Terminated			Comments*
		1	2	3	
1	85% soil density no rock	33		27	No leakage at 11,700 lb/ft ² (H = 97 ft)
4	65% soil density no rock	30		25	No leakage at 5,840 lb/ft ² (H = 48 ft)
		43			No leakage at 11,687 lb/ft ² (H = 97 ft)
2	85% soil density with rock	33	43	32	No leakage at 11,700 lb/ft ² (H = 97 ft)
3	65% soil density with rock	20	43	18	Joint leaked at 4,370 lb/ft ² (H = 36 ft)

* Leakage test conducted with 3.5 psi air pressure held for five (5) minutes>

Infiltration. When system integrity precludes the possibility of root intrusion in sewer pipe, another major problem, infiltration, is effectively eliminated. PVC sewer pipe with gasket joints can easily satisfy a maximum infiltration limit of 50 gallons per inch of diameter per mile per day. The superintendent of a large sewer system in Illinois reported that severe infiltration problems influenced his decision to try PVC sewer pipe seven years ago. He advised that "PVC sewer pipe greatly reduced infiltration problems" in his system. As a result, in the last three years he has used nothing but PVC sewer pipe in his system.

Slime Accumulation and Corrosion. Evaluation of slime accumulation in PVC sewer pipe has been difficult. Sliming conditions vary with changes in wastewater, ambient temperature, flow velocities and flow volumes. We have not received reports on wastewater collection systems where sliming has proven to be a problem in PVC sewer pipe.

Perhaps, the greatest concern regarding slime accumulation in sanitary sewer pipe relates to the generation of sulfuric acid (H₂SO₄). In a sanitary sewer the generation of sulfides principally occurs within the slime layer that can accumulate on the inner wall. Severe corrosive conditions can occur in some sewer pipes when sulfuric corrosive conditions can occur in some sewer pipes when sulfuric acid is derived through the oxidation of hydrogen sulfide by bacterial action on the exposed sewer pipe wall above the wastewater flow level.

Polyvinyl chloride (PVC) is essentially inert in the presence of dilute sulfuric acid. In consequence, the advent of severe corrosive conditions subsequent to slime accumulation is not a problem in PVC sewer pipe.

When wastewater system operators have considered it necessary to perform maintenance on PVC sewer pipe to remove accumulated slime, they commonly use high-pressure hydraulic cleaners, "pigs" or "balls."

Occasionally, system operators have expressed concern regarding use of "pigs" or "balls" in maintenance of a sewer pipe that is designed to deflect. No difficulties have been reported in use of "pigs" in cleaning of PVC sewers. One wastewater district reported that in the cleaning of a "deflected" PVC sewer pipe they found it desirable, for optimum efficiency, to remove some air pressure (about 4 psi) from their inflatable cleaning ball.

The operations manager of a California sanitary district offered his comments on cleaning deflected pipe:

"After 30 years of maintaining a collection system of (mostly) round pipe, the thought of permitting something out-of-round to become a part of that system was disturbing. We questioned whether we could clean and maintain a deflected, thin-walled plastic pipe with the equipment and techniques available to us. Could we do it without tearing up the pipeline or the equipment -- Our answer turned out be to 'yes'."

Grease Deposition. Occasionally, in sanitary sewers excessive grease deposition can create problems. Of course, in the most severe cases the accumulated grease will be present in hard-packed deposits. In some cases, high-pressure hydraulic cleaners can remove grease deposits; however, occasionally mechanical cleaning tools (e.g., cutting blades) are required. Such tools have been used without difficulty in PVC sewer lines.

A major California sanitary district reported that the potential for grease build-up, because of irregular grade and low flows, is "just as great in PVC as other products." However, they reaffirmed the common opinion that grease accumulation in a properly designed and installed PVC sewer system is not significant. The operations manager of a wastewater system in a major Texas city reported that grease deposition in sewer pipes, in his opinion, varies considerably according to conditions. He noted that he had experienced no particular problems in cleaning PVC sewer pipe with grease deposits over a period of about 10 years. A major metropolitan district in Connecticut reported that they have no record of grease buildup in any plastic sanitary sewer pipes over a period of 17 years. The district reported that they have records of continuing grease buildup in some non-plastic lines that have grades, flow velocities and wastewaters comparable to those experienced in PVC sewer lines.

Obstructions. Perhaps, it is inevitable that, on occasion, maintenance procedures will be required to remove obstructions in sanitary sewer lines. Commonly, when this problem is experienced, mechanical cleaning devices are required.

Response to this potential crisis is similar in most sanitary district. The scenario is typical. An angry homeowner calls with unflattering opinions of the city sanitary system management and urgent concerns over a stoppage in a sewer line. The maintenance crew is dispatched with rodding equipment. Perhaps, they find the stoppage in an eight-inch mainline. They immediately run a four-inch root auger through the line. Having broken up the stoppage, they then flush the line clean. The crew returns tired and dirty -- frequently without "thanks."

Obviously, the above described maintenance procedures will typically be effective in most sewer pipes -- VCP, concrete, A/C or PVC. However, on occasion, engineers and operators express concerns regarding the potential for damage to PVC pipe by rodding equipment, root augers, etc.

The first concerns regarding damage to PVC pipe by mechanical cleaning equipment were directed toward small diameter, "drain, waste and vent" PVC pipe used in house plumbing. In 1963 research was conducted in Aurora, Ohio, to determine the effects of cleaning this pipe with an electrical sewer-pipe auger. A four-inch diameter assembly made from PVC pipe and fittings (*e.g.*, wye, elbow) was plugged with debris (*e.g.*, rags, paper and rubber). The debris was rammed tightly into the pipe assembly. Water was poured into the assembly to verify stoppage and to simulate realistic conditions.

The four-inch piping assembly was then cleaned with a 3.5 inch coiled, saw-tooth edge cutting tool. The rotary cleaning tool was moved through pipe and fittings to the point of obstruction. After five minutes of forcing, the cutting tool broke through the hard-packed stoppage. At no time did the cleaning tool penetrate the wall of the PVC DWV pipe or fittings.

The pipe and fitting assembly was then cut along its length to permit inspection. After thorough examination it was reported:

"The conclusive results of this test showed that a rotating cutter blade, although smaller in diameter and subjected to more whip and play, did not abrade, cut, scratch or physically mar the inside surface of the Schedule 40 PVC-1 Drain, Waste and Vent pipe or fittings."

Similar tests were conducted to evaluate the effect of standard rotary-blade sewer cleaning equipment on PVC sewer pipe. These tests were conducted in Newark, New Jersey, in 1975.

An assembly of PVC sewer pipe was prepared as shown in Figure 3. Blockages (about one foot in length) were placed as shown. Blockages were prepared using "compacted wet excelsior, paper diapers, sand, toilet tissue, soap pads, sanitary napkins, wooden sticks and sponges." In addition, the eight-inch diameter pipe was flexed with mechanical clamps at three locations as shown to develop deflections of 5, 10 and 15 percent. The pipe tested was manufactured to meet ASTM D 3034.

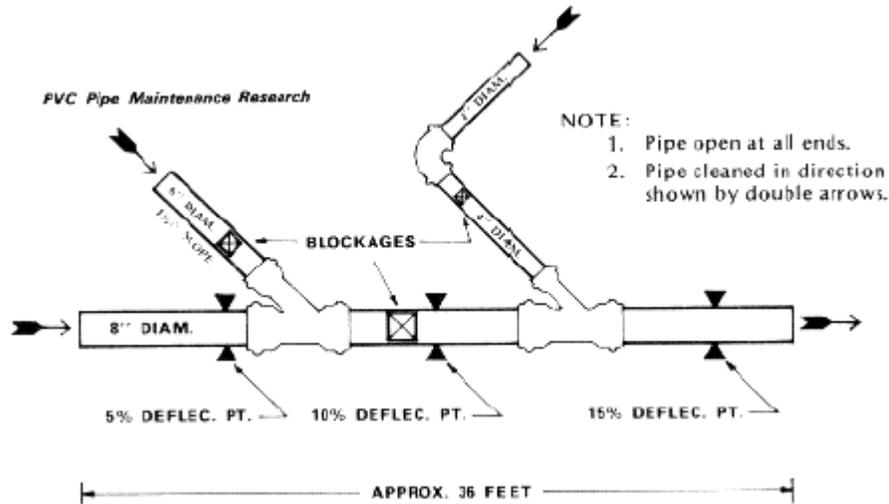


FIGURE 3
TEST APPARATUS SET-UP -- (PLAN VIEW)
(Not to Scale)

The pipe assembly was then cleaned using a Roto-Rooter[®] Sewer Cleaning Machine Model No. 55 with 5.5" cutting blade (for 8 and 6 inch lines) and 3" cutting blade (for 4 inch lines). The cleaning tool was rotated at approximately 175 RPM. The rotating blades were forced through all stoppages. The blades were then run in and out of each length of pipe and each fitting 15 times to stimulate repetitive cleaning procedures. At no time did the cleaning apparatus cut through the wall of the pipe or fittings.

After cleaning operations, the piping assembly was cut into numerous short lengths to facilitate inspection. Careful inspection revealed minor surface scratches and evidence of slight to moderate abrasion in several locations. At the point of 15 percent deflection, the testing laboratory reported, "surface scratches with moderate abrasion at point of deflection."

The laboratory reported minor "surface gouges" in the four-inch elbow. The testing laboratory's final conclusion was:

"Overall, wall thickness was not reduced and no section was damaged to any critical extent as a result of this test."

Although laboratory data and field experience demonstrate that PVC sewer pipe can be cleaned with mechanical devices without difficulty, reasonable care is advised. A California sanitary district reported one unfortunate experience in cleaning of a PVC sewer line. A maintenance crew when rodding a non-plastic sewer line, "inadvertently entered a PVC sewer line" without knowledge of change in the pipe material. In rodding, they "cut a hole through the side of a tee fitting." The district operations manager considered the circumstances extraordinary and does not fear reoccurrence. He has "not found cutting problems any other time in PVC sewer pipe or fittings when rodding." Other PVC sewer system maintenance personnel expressed surprised at this report.

The water and sewer superintendent of a city in Missouri reported, "We have PVC sewer pipe in our system which has been in service for 16 years. On rare occasions, we have removed blockages in our PVC sewers using an electric eel and a corkscrew. We have experienced no problems using this type of cleaning equipment in PVC sewer pipe."

Grit Accumulation. In some sanitary sewer collection systems grit accumulation can prove to be a problem. Frequently, preventive maintenance procedures using high-pressure hydraulic cleaners, "pigs" or "balls" can remove moderate grit deposits. If grit deposits are severe, "buckets" may be used. Of course, system managers strive to insure that their systems are designed, installed and regulated to prevent severe grit deposit problems.

An experienced manager of a large sanitary district advised: "Always get the best initial installation. That is the life and death of system maintenance." Proper installation can preclude most deposition problems. A sanitary sewer system manager in Texas advised that he had successfully removed a large deposit of rocks in a PVC sewer line (caused by children with misdirected energy) using a bucket. He noted evidence that he had scraped and scratched the inner wall of the pipe; however, the pipe remains in service without problem.

Abrasion. On occasion, concern is expressed regarding the potential damage that could be caused by abrasion. Engineers and operators may fear the effects of abrasion caused by moving sand and grit, as well as repetitive cleaning procedures in PVC sewer pipe. It should be noted that PVC, as well as some other solid wall plastic pipes, are commonly used in pneumatic conveyance systems for the transport of solids (*e.g.*, mill tailings, aggregates, ore, food materials, etc.). Such conveyance systems typically suffer under extremely abrasive conditions. PVC pipe is frequently selected because in such applications the pipe can out-wear many types of metal and non-plastic pipes. PVC pipe is well suited for gravity flow systems where abrasive conditions can be promoted by water transport of solids.

Research was conducted in 1972-73 at the Institute of Hydromechanic and Hydraulic Structures of the Technical University of Darmstadt (W. Germany). Testing was performed to evaluate the relative abrasion resistance of several pipe products used in sanitary sewers. A slurry of Rhine River sand and gravel mixed with water was placed in pipe specimens that were then mounted on "tipping racks." The incline of the pipe specimens was alternated repeatedly in a manner similar to a child's "teeter-totter." The amplitude of the up and down movement was selected to insure that abrasive material was moving even on the roughest surfaces. The sand and gravel slurry was replaced after every 200,000 alternating cycles. Results from their research were reported as follows:

- Concrete (without lining) - measurable wear at 150,000 cycles
- Concrete (with lining) - measurable but displaying less wear at 150,000 cycles
- Vitrified Clay (glaze lining) - minimal wear at 260,000 cycles (accelerated wear after glazing wore off at 260,000 cycles)

- PVC Pipe - minimal wear at 260,000 cycles (about equal to glazed vitrified clay, less than VCP after loss of VCP glazed lining)

It can be stated simply, that if severe abrasion is anticipated in a sanitary sewer, PVC sewer pipe is a good selection.

RECOMMENDED PROCEDURES FOR MAINTENANCE

Having reviewed and analyzed PVC sewer pipe response to common aggressive environments, it is not difficult to offer recommendations for proper maintenance.

Technology currently employed in the maintenance of most sanitary sewer systems (VCP, Concrete, A/C, PVC) is generally summarized as follows:

1. Periodic Inspection
 - Visual
 - Television
2. Scheduled Preventive Maintenance
 - Hydraulic Flushing
 - High-pressure hydraulic cleaning
 - Cleaning "balls"
 - Cleaning "pigs"
 - Rodding (occasional)
 - Bucket Cleaning (occasional)
 - Relining (occasional)
 - Grouting (occasional)
3. Unscheduled Emergency Maintenance
 - High-pressure hydraulic (occasional)
 - Rodding
 - root augers
 - root saws
 - blades
 - Buckets

Although some of the above listed cleaning methods may never be used in the maintenance of PVC sewer pipe, no characteristic of the pipe material renders common cleaning procedures impractical or uneconomical. In general, common sense prevails in the cleaning of PVC sewer pipe. Maintenance procedures, when required, are obvious and work well. No documented report has been received from a sanitary district that demonstrates exceptional problems or costs in the maintenance of PVC sewer pipe.

Today, many major sanitary sewer districts perform routine maintenance of PVC sewer pipe with high-pressure cleaners. The economies of this maintenance procedure are obvious when compared with the effective cost of rodding. However, high-pressure cleaning is not suitable in many cases for the maintenance of some sewer pipe materials which are extremely vulnerable to root intrusion and, therefore, does not typically require rodding.

Invariably, in the long term, scheduled preventative maintenance proves to be less expensive than unscheduled emergency maintenance.

A major factor in the cost of sanitary sewer maintenance relates to the selection of sanitary sewer pipe materials that do not require extensive maintenance. Many major municipal systems and sanitary districts are, today, selecting sanitary sewer pipe that assures reasonable and acceptable maintenance costs. PVC sewer pipe satisfies such needs.

When asked for specific information on cost of PVC sewer pipe maintenance, a California manager of system operations responded, "PVC sewer requires practically no maintenance. I have yet to find a severe maintenance problem in PVC sewers."

A Missouri city water and sewer superintendent advised, "Our maintenance problems with PVC sewer pipe in 16 years have been practically nil."

The public works department of a major Texas city advised that low maintenance cost has been a prime consideration in their decision to specify PVC sewer pipe.

A Connecticut city's division engineer reported, "We have found that PVC piping materials . . . do not need maintenance of any sort when the discharge of sewage meets with our ordinance requirements."

A city in Virginia reported that they specify PVC sewer because they can easily hold infiltration to reasonable limits.

No cities have expressed fears regarding bad experiences with PVC sewer in systems where severe sulfide corrosion is common.

CONCLUSION

An engineer or an operator would be ill advised to assume that any sanitary sewer pipe product can invariably offer maintenance free service. Reasonable inspection and proper preventive maintenance procedures for all sanitary sewer systems are generally well advised. PVC sewer pipe, of course, cannot be considered the perfect solution to all sanitary wastewater collection problems; however, experience demonstrates that it can solve many common maintenance problems.

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